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Volume VIII FEBRUARY, 1926 Number 2

THE JOURNAL OF INDUSTRIAL HYGIENE

AND ABSTRACT OF THE LITERATURE

Official Organ of The American Association of Industrial Physicians and Surgeons

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Some of the Potential Public Health Hazards from the Use of Ethyl Gasoline

Four Cases of Poisoning by Mononitrochlorobenzene, and One by Acetanilide, Occurring in a Chemical Works: With an Explanation of the Toxic Symptoms Produced

Prophylaxis in Industrial Lead Poisoning

The Organization and Operation of an Industrial Health Department: A Description of the Work of the Department of Health of the Tennessee Coal, Iron and Railroad Company

Published Monthly at Mount Royal and Guilford Aves., Baltimore, Md.
by HARVARD MEDICAL SCHOOL

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Managing Editors

Journal of Industrial Hygiene

55 Van Dyke Street

Boston, Mass.

THE JOURNAL OF INDUSTRIAL HYGIENE

PUBLISHED MONTHLY

VOLUME VIII FEBRUARY, 1926 NUMBER 2

SOME OF THE POTENTIAL PUBLIC HEALTH HAZARDS FROM THE USE OF ETHYL GASOLINE*

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THE Laboratory of Industrial Hygiene of Columbia University was requested by the Medical Committee of the Ethyl Gasoline Corporation to undertake an investigation as to the possible hazards that might arise from the use of tetraethyl lead in the gasoline sold to automobilists.

Tetraethyl lead is a colorless liquid with a specific gravity of 1.62 at 15°C., boiling at 200°C., but not without some decomposition. It is a lipoid solvent, attacks rubber, and is insoluble in water. The fact that it is a lipoid solvent brings us face to face with a possible lead hazard through skin absorption. When exposed to sunlight or evaporation, it decomposes and forms as one of its decomposition products triethyl lead, a poisonous compound whose pharmacologic properties have been studied by Harnack.[1] When used in the automobile, it is added to gasoline, together with an organic halide, in the proportion of 1,300 parts of gasoline to 1 part of the lead compound; this mixture being known to the trade as ethyl gasoline. The purpose of adding the organic halide is to assist in the removal of the lead from the motor after combustion. When the Laboratory at Columbia University was requested to undertake this study, it was still proposed to use the 1,000 to 1 mixture.

As the United States Bureau of Mines had already been studying for some months the possible hazard to the public from the lead in the exhaust gases of engines using this ethyl gasoline, the Medical Committee sug-

* Received for publication Sept. 1, 1925.

[1] Harnack, E.: Ueber die Wirkungen des Bleis auf den thierischen Organismus. Arch. f. exper. Path. u. Pharmakol., 1878, *9*, 158.

gested that Columbia University confine their efforts to the following hazards:

1. The possible hazard to the tank man, garage man, or anyone who might get a few drops of the concentrated material on his clothes or person from time to time when handling tetraethyl lead.

2. The possible hazard that might arise from splashing the ethyl gasoline (1,000 to 1 mixture) on the person; or from the cleansing of the hands or clothes by the mechanic or by the housewife; or while adjusting the carburetor or cleaning out the gas line or tank; etc.

3. The possible danger from the inhalation of ethyl gasoline fumes from spillage in the garage and other places where vaporization may take place.

Before our experiments were productive of results, an unfortunate experience occurred in an experimental plant of the Standard Oil Company of New Jersey at Bayway, which was engaged in a study of an improvement in the method of manufacture of tetraethyl lead. A number of the employees working in this plant became poisoned at one time and were placed under observation at the Reconstruction Hospital, New York City. Before their removal to the Hospital, one of the men died. The symptoms of the worst cases were those described by several writers in cases of acute lead poisoning and were very similar to those produced by ethyl alcohol. Indications of profound cerebral disturbances were present in the more severe cases. The victim suffered from persistent insomnia and became delusional, extraordinarily restless and talkative. There was an exaggerated movement of all muscles of the body. The patient became maniacal and died of exhaustion. Four of the men transferred to the Hospital died within a few days. The rest of the men were discharged from the Hospital after receiving the proper treatment.

We took advantage of the opportunity to study these cases at the Reconstruction Hospital so that we would be in a better position to interpret our animal work. We found lead in the stools of eighteen out of twenty-nine men that were examined. This continued to be present for several months after removal from exposure. We could not detect any lead in the sweat of men subjected to thermal baths. Tests were also made on the skin with ammonium sulphide, but the findings were negative. Several specimens of spinal fluid also gave negative results. Stippled cells were found in the blood of nine out of twelve men examined by this Laboratory. The findings of the laboratory at the Hospital on a larger group of men indicated that 50 per cent. of the men who had been exposed showed stippled cells in the blood.

The report of the chief examiner of New York City on the autopsies performed on the four men who died at the Hospital reveals no gross pathologic findings. No one would have been able to say that lead was the cause of their deaths without a chemical analysis or without knowledge of where the men had worked. This of course is in agreement with our past knowledge as to the pathologic and histologic findings in lead cases.

The autopsies determined the cause of death "pending chemical examina-

tion and investigation as 'hemorrhagic broncho-pneumonia, visceral congestion' in two cases; 'hemorrhagic broncho-pneumonia, secondary anemia' in the third; and in the fourth 'general visceral congestion.'" We have given these data as an aid to a better understanding of our own findings.

After the unpleasant accident at Bayway the Ethyl Gasoline Corporation decided to remove any possible hazard to the general public, including the garage man, from any contact with the concentrated tetraethyl lead, by delivering only the 1,300 to 1 mixture to the filling stations. As a further precaution, it is intended to add a red dye to the gasoline so as to lessen the possible hazard through skin absorption when handling the dilute mixture. This dye would act as a deterrent to the housewife or the mechanic who might otherwise be tempted to use some of the gasoline for cleansing purposes.

This precaution would also serve as a warning against the use of ethyl gasoline in gasoline stoves for cooking purposes, as well as in the gasoline torches used by painters, plumbers, etc. We have seen evidence that fine lead is given off when this gasoline is burned in such apparatus and that this fine lead remains in suspension for several days. Just what the extent of this particular hazard is, we cannot say as we have made only the most preliminary tests. But it will be necessary to educate the public—if it is possible—to use ethyl gasoline only in the automobile.

Procedure in Animal Experiments

Chemicals

The tetraethyl lead used in these experiments was furnished by the Medical Committee of the Ethyl Gasoline Corporation and was supposedly the pure product. We purchased our gasoline from a filling station in the neighborhood of the Medical School and made up our own mixture from time to time as we needed it.

Animals

We used matured rabbits, guinea-pigs, rats, goats, pigeons, and monkeys in our work. The animals were kept under observation for a period of time before they were subjected to any exposure, and their weights and temperatures were noted during the whole series of experiments. The red and white and differential cell counts were made periodically on the blood of the goats and the rabbits. The blood smears were carefully examined for stippled cells. The control animals were kept away from the exposed animals so that they would not have a chance to accumulate lead in any way. Outside of this precautionary measure, all of the animals were treated in the same manner. Samples of feces were collected from time to time and examined for lead.

Method of Examination

Blood.—Three stains were used in examining the blood for stippled cells—Wright's, Glibert's, and Harlow's methods, as used and recommended by the Division of Industrial Hygiene, Provincial Board of Health of Ontario.

Lead.—The bodies were burned at a low temperature over a gas flame so as to avoid any volatilization of the lead. The chromate method de-

scribed by Fairhall was used in the actual determination of the lead. We found it necessary to make our solution almost alkaline if not alkaline, in order to be sure that the lead was precipitated out by the hydrogen sulphide. This, of course, necessitated the redissolving of the sulphide precipitate in a small amount of nitric acid and a reprecipitation by hydrogen sulphide.

Skin Absorption Tests

Dosing of the Animals

We determined at the beginning of our work that a man would have approximately 10 c.c. of gasoline left on his hands after washing them and before drying them on waste or a towel. Using this as a basis, we dosed our animals in the same proportion by weight, taking the weight for man as 70 kilos. We felt that this was as near as we could come to duplicating an industrial condition. Of course a man in a garage may wipe his hands dry, but our observations have led us to doubt it unless he is washing up preparatory to going home. Generally the last traces dry off by vaporization. In the case of a spillage the exposure would be much greater, and the average man will not change his garments if gasoline spills on them, preferring rather to let the gasoline evaporate. However, one may be sure of a greater absorption with the larger exposure if lead storage took place with our comparatively small daily exposure. Even if the man's exposure should not occur daily, there is bound to be some storage of lead as the rate of excretion does not equal the rate of absorption. Whether the exposures will be frequent enough or great enough to make this storage of lead a factor in the man's health is a matter for the health officer and the doctor to determine as they come in contact with those exposed.

We applied the ethyl gasoline to the skin by means of a small pipette. The gasoline was permitted to flow slowly from the pipette on to the uninjured skin by pushing the hair aside whenever it was possible. When we found it necessary to shave the animal, several days were allowed to elapse to permit the skin to heal before it came in contact with any gasoline. We took care in all of our work never to apply the ethyl gasoline to any broken skin. Also, because our observations showed that the gasoline affected the cutaneous tissue, we varied the surface area of the gasoline application from day to day. We did not wipe off the gasoline from the skin once it had been applied, but permitted it either to vaporize or to be absorbed. We felt that our problem consisted in determining whether lead could be absorbed from the ethyl gasoline into the body. If lead is shown to be absorbed, the precaution of wiping off any gasoline that might come in contact with the skin is a part of the educational program that must be undertaken if ethyl gasoline becomes very generally used. We exposed the animals daily except on Sundays and holidays and when feces were being collected.

We were very skeptical at the beginning of our work as to whether or not there was any skin absorption, but felt rather that the actual poisoning took place through ingestion or inhalation. Rabbits and guinea-pigs have the habit of cleaning their fur

with the tongue, and they can be seen doing this not only to their own bodies, but to other animals of the same species. We tried to overcome this by placing jackets on the animals, but these jackets got torn and observations led one to believe that they interfered with the physiologic activities of the animal—probably the heat regulating mechanism. At any rate, the normal animals died as readily as the exposed ones. On account of this fur licking habit, we decided to use goats as well as the smaller animals in our work. The goat is a hardy animal, not susceptible to pulmonary diseases, and, as far as we have observed, has no tendency to lick itself.

Test Experiment

In order to determine whether absorption actually did take place through the skin and not by ingestion or inhalation, we decided to make the following test, which was repeated at three different times.

A cat was anesthetized with ether. Tracheotomy was performed and a cannula placed in the carotid so that the blood pressure and the respiration could be observed. The tube from the trachea was led away from the body in such a way as to preclude any chance for the animal to inhale any fumes. In order further to safeguard against the breathing in of any tetraethyl lead fumes, an exhaust fan was placed near the abdomen and an electric fan at the head of the cat. Six cubic centimeters of the concentrated tetraethyl lead were allowed to flow from a pipette on to the clipped abdomen and a record was taken on the kymograph. As far as our records show, there did not seem to be any change in the blood pressure or the respiration. The cats died at different intervals, varying from eleven minutes to two hours. A slight abrasion was noticed in the skin of the animal dying in eleven minutes. As soon as the cat died the skin was cleaned with alcohol, to remove any tetraethyl lead remaining on it. The skin was quickly removed and the abdomen opened for examination. In each case blisters were observed all through the abdominal region and the intestines had a peculiar bluish hue. The odor of the tetraethyl lead was quite distinct when the body was first opened. After this gross examination, the whole body with the exception of the skin was burned and the lead contents determined. The average lead content of the three cats used in this experiment was found to be 0.651 gm. of lead. Probably the lead contents would have been greater if it had not been for the excessive ventilation maintained to prevent any possible inhalation of the fumes.

This experiment would seem to indicate that there is no doubt that this lead compound is readily absorbed through the skin and that it must be immediately washed off the skin with green soap and kerosene if it should by any chance get on the body. Water and ordinary soap will not remove it. The Ethyl Gasoline Corporation is to be commended on its action in removing this concentrated compound from the public.

Summary of Hazards from Skin Contact

Rabbits, guinea-pigs, and goats were used in this part of the study which had to do with the possible hazards that may exist from ethyl gasoline

coming in contact with the skin and a subsequent absorption into the body of the minute quantity of the lead compound present in the gasoline.

We are giving a summary of our findings because, as we have stated before, the problem consists in determining whether lead can be absorbed and stored in the body. It is not necessary for us to prove that the animal died of lead poisoning or how much lead the organism can store before any marked pathologic symptoms appear. The individual idosyncrasies vary too much to make these facts of supreme importance. Furthermore, there is no doubt that there are many persons engaged in the industries who are subject to lead exposures. The storage ability and excretory power of these persons may just balance the lead intake and any excess exposure may be enough to push them over to the wrong side of the line.

Experiments on Rabbits:

Each animal received 0.3 c.c. of the 1,000 parts of gasoline to 1 part of tetraethyl lead mixture practically daily until it died. The results of these experiments are given in Table 1. The number of exposures that the animal underwent varied from 6 to 187. Twenty-eight animals have died. The average findings on these animals are:

	Temperature	*Weight*	*Red Blood Count*
	°C.	*kilos*	*per c.mm.*
Initial.....	38.9	2.07	4.88
Final.....	38.8	2.03	4.86

Stippled cells were found in the blood of fourteen of the rabbits. These rabbits did not show any stippled cells at the beginning of their exposure. The two rabbits which died after they had been treated but 6 and 13 times, respectively, showed only traces of lead in their carcasses after they had been burned. An average of 1.93 mg. of lead per kilo of body weight was found to be present in the carcasses of the rabbits that died in this part of the study. The quantity of lead accumulating in the body does not always follow the number of exposures to which the animals are subjected; but there seems to be no doubt as to the tendency for an increased amount of lead storage in the body with the longer exposures.

Excretion.—The average rate of excretion as shown by frequent examination of the feces is approximately 0.044 mg. per twenty-four hours, and, so far as our observations go, does not seem to increase with a greater storage.

Behavior.—The animals did not show any signs of ill health during the exposure until several days before they died. During the last two or three days before death the animal as a general thing became quiet and frequently hunched up as if suffering from colic. If the animal was removed from the exposure as soon as the first symptoms of ill health appeared, it soon recovered. Four of the animals developed tremors and spasms just before the end. One of the rabbits which had received 185 applications became completely paralyzed in the hind quarters two days before death. This rabbit showed 4.9 mg. of lead per kilo of body weight. Several of the rabbits aborted, but the fetuses were not examined for lead.

Autopsy.—An autopsy was performed on each animal that died and revealed nothing more than was found

in the control animals when they were killed or died except that there was the consistent presence of a white blood clot in the right auricle of the leaded animals. This was also observed in several supposedly sound animals. The ante mortem clot is usually accounted for by a slowing down of the circulation. If this is the correct explanation it will corroborate what has been observed on men who have been exposed to the compound, namely, a lowered blood pressure. One man, in whose twenty-four-hour urine sample we had found 12 mg. of lead, had a systolic pressure of 90.

TABLE 1.—RESULTS OF EXPERIMENTS ON TWENTY-EIGHT RABBITS THAT DIED AFTER BEING TREATED WITH ETHYL GASOLINE

(Dosage: 0.3 c.c. of 1,000 parts gasoline to 1 part tetraethyl lead)

NUMBER OF ANIMAL	NUMBER OF DOSES	TEMPERATURE		WEIGHT		RED BLOOD COUNT		STIPPLING[1]	LEAD PER KILO OF BODY WEIGHT
		Initial	Final	Initial	Final	Initial	Final		
		°C.	*°C.*	*kilos*	*kilos*	*per c. mm.*	*per c. mm.*		*mg.*
8[2]	85	39.4	39.2	1.53	1.70	4.58	4.82	+	3.44
9	49	39.2	38.5	3.31	2.12	5.20	5.20	+	0.78
12[2]	44	39.0	38.9	2.17	1.76	5.72	5.31	−	0.86
13	85	39.0	38.9	1.63	1.71	4.09	4.64	+	3.23
14[3]	185	39.0	39.2	2.35	3.13	4.35	4.72	+	4.90
16	52	39.0	38.8	1.57	1.87	4.68	4.61	−	0.85
17	77	39.0	39.2	2.29	2.03	4.55	4.60	−	2.30
18	74	39.0	38.4	1.95	1.40	4.37	4.86	−	1.83
19	35	38.6	38.3	2.02	1.91	4.54	4.62	−	0.50
20	6	38.6	38.6	2.07	2.07	4.38	4.62	−	trace
21	17	38.6	38.1	2.47	2.38	4.74	4.86	−	0.30
23	13	38.6	39.5	2.37	2.31	4.88	4.80	−	trace
24	61	39.0	38.6	2.27	2.13	5.30	4.90	−	3.15
26	24	38.4	38.8	2.02	1.38	4.82	4.86	+	1.97
30	175	38.0	38.6	1.64	2.01	4.82	4.88	+	3.90
31	42	39.2	38.7	1.73	1.72	4.65	4.88	−	1.75
33	52	39.4	39.2	2.30	1.90	4.66	5.00	−	1.82
34	187	39.8	39.0	1.81	2.75	5.02	4.87	−	1.79
35	70	39.2	39.2	1.37	1.50	5.14	5.02	+	3.38
36	175	39.0	38.8	1.63	2.22	5.06	4.88	+	4.05
37	27	38.8	38.8	1.34	1.15	4.82	4.60	+	1.20
38	45	38.8	38.8	1.61	1.70	4.82	4.60	+	1.85
40	70	39.0	39.0	2.46	2.54	4.87	4.80	+	2.68
41	25	38.8	38.8	1.45	1.00	4.68	4.64	−	1.15
50[2]	36	38.9	39.0	3.42	3.33	5.45	5.04	+	1.54
75[2]	35	38.6	38.8	2.65	2.34	5.58	5.76	+	1.72
76	24	39.0	39.0	1.88	2.00	5.10	4.71	+	1.38
77	45	39.0	39.2	2.86	2.90	5.77	5.12	−	1.78

[1] + indicates stippled cells found; − indicates no stippled cells found.
[2] These rabbits showed tremors and spasms before death.
[3] This animal became completely paralyzed several days before death.

Experiments on Guinea-Pigs:

Ten pigs were used in this part of the experiment. They received 0.1 c.c. of the 1,000 to 1 mixture on their unbroken skin daily until death (see Table 2). The number of exposures varied from 2 to 46. The average initial weight was 0.449 kilos and the average final weight 0.394 kilos. The average lead per kilo of body weight was found to be 0.855 mg. Three pigs had convulsions and tremors before death.

TABLE 2.—RESULTS OF EXPERIMENTS ON TEN GUINEA-PIGS TREATED WITH ETHYL GASOLINE

(*Dosage: 0.1 c.c. of 1,000 to 1 mixture*)

NUMBER OF ANIMAL	NUMBER OF DOSES	WEIGHT		LEAD PER KILO OF BODY WEIGHT
		Initial	Final	
		kilos	*kilos*	*mg.*
8	26	0.315	0.290	1.10
9[1]	23	0.330	0.290	1.25
10	30	0.367	0.324	1.50
11[2]	4	0.352	0.332	trace
12[2]	2	0.298	0.310	trace
13	23	0.267	0.260	1.20
14[1]	18	0.587	0.545	1.00
15	8	0.637	0.632	0.00
16[1]	46	0.715	0.340	1.75
17	10	0.620	0.620	0.75

[1] These animals had tremors and convulsions before death.

[2] These animals were sacrificed to see if any lead was being absorbed at the time of the trouble at the Bayway Plant.

Experiments on Goats:

Seven goats were given 2 c.c. of the 1,000 to 1 mixture daily by skin application (see Table 3). Their exposures have varied from 86 to 114. Two of these goats have aborted and an analysis of the fetuses showed that they contained an average of 3.45 mg. of lead. Stippled cells were not found in the blood for over two months after the exposures began but they have increased in numbers as time went on. One goat which had received 114 doses of the dilute solution showed a marked muscular weakness in the hind quarters. One other goat showed the same effect to a slight degree.

TABLE 3.—RESULTS OF EXPERIMENTS ON GOATS TREATED WITH ETHYL GASOLINE

(*Dosage: 2 c.c. of 1,000 to 1 mixture*)

NUMBER OF ANIMAL	NUMBER OF DOSES	STIPPLING[1]	REMARKS[2]
88	114	+	Daily rate of excretion 0.1 mg. The animals are still alive.
89	86	+	
90	86	+	
91	86	+	
92	87	+	
93	86	+	
94	86	−	

(*Dosage: 1 c.c. of concentrated tetraethyl lead*)

95	60	−	Daily rate of excretion 0.56 mg.
4016	59	+	

[1] + indicates stippled cells found; − indicates no stippled cells found. Stippling did not begin to show in these animals until they had received a number of doses.

[2] Goat 88 showed weakness in the hind quarters and was very nervous. Goats 88, 93, 95, and 4016 each aborted.

Goat 93 showed weakness especially in the left hind leg.

Goats 95 and 4016 were very quiet and stood hunched up at times as if they had colic.

Two goats were given 1 c.c. of the concentrated tetraethyl lead daily for

approximately two months. Both of these goats have aborted. One died after receiving 60 exposures. It had very marked weakness in the hind quarters for several days before it died. The day that it died it was unable to stand or to use its hind limbs, and spent the whole day crying. An analysis of the various organs showed the lead to be distributed in the following manner:

	Weight	*Lead Content*
	gm.	*mg.*
Brain	60	3.36
Lungs	250	1.74
Kidney	75	0.80
Liver	250	1.85
Heart	125	2.93
Muscle	...	0.67[2]
Bone	...	4.86[2]
Intestines	not taken	3.27

Both of the goats receiving the concentrated lead compound remained quiet and hunched up as if in pain most of the time.

The goats being treated with the 1,000 to 1 mixture excreted an average of 0.1 mg. of lead each twenty-four hours. The goats receiving the concentrated tetraethyl lead excreted an average of 0.56 mg. each twenty-four hours.

Fume Hazard Tests

At the very beginning of our work we realized that it would be hard to duplicate the actual conditions that may be present around a filling station or a garage. No data were available as to the concentration of gasoline that may occur at such localities. These data would have been very valuable to us in planning our work. Numerous inquiries at filling stations seem to indicate that, if a man were careful, the spillage around a pump should not amount to more than 1½ gallons a day. But even if this amount is correct, the concentration in the immediate atmosphere would vary from time to time, depending on the area over which the gasoline spread itself, on the temperature, and on the air movements. Again it does not necessarily follow that the man at the station is exposed to the fumes for more than a few minutes at a time or for many minutes a day. In considering this hazard one must bear in mind that R. P. Albaugh[3] has shown that when a man is exposed to a mixture of air and benzene 80 per cent. of the benzene is absorbed. The same thing may be expected to hold true for a mixture of air and gasoline. If this gasoline should contain lead, it would be a most excellent method for getting the metal into the body through the lungs.

Through Evaporation in a Gas Chamber

In our study of the ethyl gasoline fumes we made use of a gas chamber containing approximately 180 cubic feet of air. The air in this chamber is changed once in ten minutes or 6 times an hour by means of an air inlet near the floor of the chamber and an outlet in the ceiling. The ethyl gasoline fumes were admitted with the incoming air in sufficient quantity to maintain a predetermined dilution of gasoline fumes in the chamber. This was accomplished by bubbling air through an ethyl gasoline mixture in a

[2] Per 100 gm.

[3] Albaugh, R. P.: Benzene Poisoning. Mod. Med., 1919, *1*, 670; abstr. in Chem. Abstr., 1920, *14*, 575.

bottle at the proper rate. We did not evaporate all of the gasoline in the bottle because it has been observed that there is a concentration of the tetraethyl lead as the lighter portions of the gasoline are evaporated. For example, we found that we would have no difficulty in evaporating 400 c.c. of ethyl gasoline spilled on nonporous material under out-of-door conditions in four hours. Four samples of 400 c.c. of gasoline were evaporated in shallow glass dishes under natural conditions out of doors. Some of the tetraethyl lead in the gasoline decomposed and the yellow crystals of hydrated triethyl lead salt were formed. An analysis of the four residues showed that they contained on the average 0.108 gm. of lead. The original 400 c.c. contained 0.372 gm. of lead. This is what one might expect under industrial conditions, and the man would also have some exposure to these fine crystals of the lead salt as well as to the ethyl gasoline fumes.

In our work we endeavored to evaporate 400 c.c. of the 600 c.c. of gasoline that the bottle would contain during the four hours that the animals were exposed in the gas chamber. As far as we could determine, the air of the chamber during our experiments contained 0.04 mg. of lead per cubic foot.

Before we exposed our animals to ethyl gasoline fumes of this concentration, we exposed them to the same concentration of gasoline fumes which did not contain lead for twenty hours a day for one week. At the end of this preliminary period, the animals showed no ill effects and we felt that our predetermined concentration of gasoline in the ethyl gasoline fumes would not injure them in any way when they were exposed for only four hours a day. Any ill effects that might be observed in the animals we felt sure must be ascribed to the lead in the ethyl gasoline fumes.

Animal Experiments:

Goats, rabbits, guinea-pigs, monkeys, pigeons, and rats were exposed in the gas chamber, for an average of four hours a day, to the fumes of ethyl gasoline of the aforestated concentration. Care was taken that no food or other material that might be gnawed was present. The only way that lead could have entered the body was through the respiratory tract unless some vapor should have been deposited on their fur, which is highly improbable. Strangely enough, our albino rats seemed more sensitive to the fumes than the rest of our experimental animals. The total number of hours that the animals were under exposure varied from 30 to 265 (see Table 4). As before, we do not claim that lead was the cause of death, especially in the cases of those animals that died after a short exposure. Smears of the goats' and rabbits' blood did not reveal any stippled cells when the exposure began, but as the number of hours of exposure increased, stippled cells were observed in every case. The animal usually became quiet and hunched up for several days before it died. As in the cases of the men at the Reconstruction Hospital and of the animals dying after skin exposures, the autopsies gave no special findings. An analysis of the carcasses of thirty-nine animals that died showed that they contained on an average 5.52 mg. of lead per kilo of body weight.

TABLE 4.—RESULTS OF EXPERIMENTS ON ANIMALS EXPOSED TO FUMES RESULTING FROM EVAPORATION OF ETHYL GASOLINE IN A GAS CHAMBER

ANIMAL	FINAL WEIGHT	HOURS EXPOSED	LEAD PER KILO OF BODY WEIGHT
	kilos		*mg.*
Monkey	3.200	30	0.075
Guinea-pig	0.552	56	0.235
Monkey	3.000	56	0.166
Guinea-pig	0.352	70	2.272
Guinea-pig	0.365	70	2.328
Guinea-pig	0.507	70	1.341
Guinea-pig	0.540	70	1.666
Rat	0.128	88	7.812
Guinea-pig	0.480	96	0.625
Pigeon	0.280	96	1.071
Rat	0.135	96	5.925
Goat	13.200	100	0.015
Rat	0.119	100	6.720
Goat	14.500	114	0.068
Rat	0.141	148	12.056
Rat	0.123	150	16.016
Rat	0.138	152	6.884
Rat	0.142	152	7.464
Guinea-pig	0.365	167	5.068
Rat	0.140	167	11.000
Rat	0.138	174	10.652
Rabbit	1.660	175	1.927
Guinea-pig	0.410	176	3.487
Guinea-pig	0.348	178	2.298
Guinea-pig	0.367	178	3.269
Guinea-pig	0.595	178	1.848
Rat	0.122	179	9.016
Rat	0.125	188	12.000
Rabbit	2.040	193	1.259
Rat	0.147	210	11.224
Rat	0.135	224	7.333
Rat	0.152	238	6.644
Rat	0.124	241	8.145
Rat	0.128	254	7.812
Rat	0.137	258	7.299
Rabbit	2.520	258	1.765
Rat	0.130	260	14.460
Rat	0.157	260	12.547
Guinea-pig	0.480	265	3.479

One of the guinea-pigs gave birth to two pigs. Neither the mother nor her young were exposed to lead after their birth. The two young pigs lived seven days, then had convulsions and died. An analysis showed that their bodies contained 0.6 and 0.68 mg. of lead, respectively.

Lead was found in the excreta of all the animals exposed. None of the control animals showed lead when their carcasses were burned and analyzed.

Through Natural Evaporation

Test 1.—This experiment took place on the roof of the building where the rate of the vaporization depended on the natural air movements and temperature during the day and night. The fumes were not confined and could disperse into the surrounding atmosphere according to the ordinary physical laws.

For this work we took a galvanized iron pan 30 inches in diameter and 20 inches deep. The bottom of this container was flat. A movable false bottom of one-half-inch mesh screen was placed 11 inches above the bottom. Each morning we poured 1,800 c.c. of ethyl gasoline on the bottom of the pan after it had been thoroughly cleaned and dried. The movable false bottom was then placed in position and on it were placed ten albino rats. The top of the pan was left open to the natural air movements, except for one-half-inch screen placed on the top to keep the rats from jumping out. The rats were exposed to the fumes resulting from the natural evaporation of the tetraethyl gasoline for twenty-two hours daily for seven days. For two hours each day, the rats were removed to give them a chance to eat and drink,

and to permit the cleaning of the container. It was observed that approximately 200 c.c. of gasoline were left unevaporated at the end of the twenty-two hours. At the end of the seven days, the rats were killed and examined. An average lead content of 26.6 mg. per kilo of body weight was found. There was no way that the rats could have come in contact with any lead except through the fumes formed by the natural evaporation of the ethyl gasoline. There was no dust, as the bottom of the pan was still moist. We feel after this experiment that there can be no doubt in our own minds that the lead concentration in the ethyl gasoline fumes is of sufficient degree to cause lead storage in the body in appreciable quantity.

In reporting this test, we do not claim that man has the same exposure that these rats had. That the exposure of the animals was not unduly severe, however, is plainly indicated by the fact that they did not exhibit any distress from the gasoline fumes, but acted in a perfectly normal manner during the whole day whenever they were observed. Of course no man will be exposed to fumes for twenty-two hours a day continuously, nor will he be standing over a pool of gasoline.

Test 2.—In order further to study the hazard of ethyl gasoline fumes we erected a pen 10 feet long, 4 feet wide, and $3\frac{1}{2}$ feet high in a large yard in a neighboring suburb. We placed a roof over the pen to shut out the rain. This roof was not very tight, however, because of cracks between the boards which permitted the escape of fumes. Three sides of the pen consisted of wire screening and the fourth side was formed by the side of a building. Any prevailing winds could sweep through the pen. The floor was made of loose stones covered with dirt. This dirt was removed from the floor every so often so as to keep the pen sanitary. About 18 inches from the open end of the pen a circular enclosure of wire netting having a diameter of 12 inches was erected and extended from the ground nearly to the roof. The bottom of this enclosure was hollowed out to a depth of 6 inches below the surface of the surrounding floor. A bucket containing ethyl gasoline was suspended, in this circular enclosure, from the roof. In this bucket were placed two lamp wicks which hung over the sides of the bucket and rested on two boards fastened together in the shape of a V. The point of this V rested on a plate in the bottom of this enclosure. The wicks permitted a slow flow of ethyl gasoline, by means of capillary attraction, from the can on to these boards. The gasoline evaporated as it flowed down the boards. Any gasoline that did not evaporate was collected in the plate and any overflow from the plate had the opportunity to soak through the loose stones into the ground. The floor of the pen did not get wet from any gasoline so far as our observations went. The bucket was loosely covered so as not to interfere with the capillary flow. We found that we could evaporate about 2 quarts of gasoline each twenty-four hours.

Fifteen rabbits were placed in this pen and were constantly exposed to any fumes that might be present in the

atmosphere. These rabbits had the freedom of the pen and could run around at will. But under no circumstances could they come in contact with any gasoline fluid. Food, which was given them twice a day, was quickly eaten. In carrying out this experiment, we felt that we were exposing the animals under more natural conditions than in some of our other work. The animals were active and showed no signs of being under any exposure. In fact anyone seeing them would say that they were in excellent condition. They all gained weight.

We did not analyze their feces nor make any blood examination as we were principally interested in learning whether or not the rabbits under these conditions would absorb lead. Visitors often remarked that the gasoline fumes were no more in evidence than around filling stations, if as much.

After these animals had been constantly exposed from June 6 to July 17, five of the animals were killed to see if any storage of lead had taken place within that time. A chemical analysis showed that they had stored an average of 1.72 mg. of lead per kilo of body weight. This experiment confirmed our previous observation as to the ease with which the lead can be absorbed by the organism from the air-gasoline mixture. We did not determine the concentration of the gasoline in the air because it varied so much with the temperature and the air movements. During the period between June 6 and July 17 we had some of the hottest weather of the year; we had also considerable cloudy weather and rain with high winds.

Possible Hazard from Contact with Tetraethyl Lead

The few experiments noted below will indicate the possible hazard from any concentrated tetraethyl lead that might be present through a concentration of the gasoline by vaporization. This hazard is also one of those with which the manufacturer has to contend.

Rabbits and guinea-pigs were used in these experiments; 0.01 c.c. of the concentrated ethyl lead compound was allowed to flow from a small pipette on to the skin of the animal daily until death ensued.

Summary of Experiments on Five Rabbits

The animals received from 13 to 19 doses before dying. The average findings are as follows:

	Temperature °C.	*Weight* kilos	*Red Blood Count* per c. mm.
Initial.....	38.7	2.2445	4.77
Final.....	39.8	2.2040	4.71

An average of 1.79 mg. of lead was found in the viscera of the rabbits (see Table 5). Stippled cells were found in two of the rabbits which received 18 and 19 doses. All of the rabbits became quiet a couple of days before they died. This quietness was succeeded by tremors, exaggerated muscular movements, and, finally, convulsions.

A histologic examination of the various organs gave no indication of any change that we could say came from the tetraethyl lead exposure. Brain lesions were observed but the same lesions are noticed in 50 per cent. of the normal animals examined.

Summary of Experiments on Five Guinea-Pigs

The pigs received from 8 to 20 doses before dying. The average initial weight was 0.345 kilos; the average final weight, 0.337 kilos (see Table 6).

An average of 4.93 mg. of lead per kilo of body weight was found in the whole carcass. The pigs all developed tremors and convulsions before death. The autopsy findings revealed nothing that was not found in control animals.

TABLE 5.—RESULTS OF EXPERIMENTS ON FIVE RABBITS SUBJECTED TO CONTACT WITH TETRAETHYL LEAD

(*Dosage: 0.01 c.c. of concentrated tetraethyl lead*)

NUMBER OF ANIMAL	NUMBER OF DOSES	TEMPERATURE		WEIGHT		RED BLOOD COUNT		STIPPLING[1]	LEAD IN VISCERA
		Initial	Final	Initial	Final	Initial	Final		
		°C.	*°C.*	*kilos*	*kilos*	*per c. mm.*	*per c. mm.*		*mg.*
1[2]	16	38.9	39.2	1.600	1.370	4.51	4.68	−	2.25
2[3]	19	39.0	38.4	3.100	3.060	4.90	4.62	+	no analysis made
3[2]	18	38.8	40.8	2.760	2.210	4.92	4.74	+	1.66
5[2]	13	37.6	38.4	2.112	1.840	4.82	4.82	−	1.73
6[2]	18	39.6	42.2	2.655	2.540	4.69	4.72	−	1.52

[1] + indicates stippled cells found; − indicates no stippled cells found.

[2] These rabbits became quiet a couple of days before their death. This quietness was succeeded by tremors, exaggerated muscular movements, and, finally, convulsions.

[3] This rabbit was sent to Presbyterian Hospital for a special histologic examination.

Control Animals

We have not detected lead in any of our control animals, as care was taken never to have them under exposure.

General Remarks

In rendering this report we realize that it is very difficult to apply animal experiments to human beings. Still we feel that our findings so far indicate a potential hazard in the use of ethyl gasoline by the public without some educational campaign. While man is not confined in the same way that the experimental animal is, and can walk in and out of the experiment, does this fact only mean that it will take a longer time before any pathologic condition may arise? The question as to what constitutes lead poisoning has to be definitely decided by the medical profession in the near future.

"Looney Gas" poisoning is a wrong terminology, and it is to be regretted that the newspapers were permitted to coin this term. Both from our own work and from that of Harnack on triethyl lead, we are inclined to feel that all of the cases on record can be described as cases of lead poisoning, either acute or chronic. Harnack showed in his work that the triethyl lead acted as the whole molecule on the circulatory and respiratory centers for a short period. If the animal survived this period, the compound broke down and an inorganic lead compound was formed in the body and all of the

secondary symptoms were those of inorganic lead poisoning. He was unable to find any of the original molecule in the bladder. We have made three or four attempts to detect tetraethyl lead in the animal several hours after an exposure to concentrated tetraethyl lead, but our results were always negative.

TABLE 6.—RESULTS OF EXPERIMENTS ON FIVE GUINEA-PIGS SUBJECTED TO CONTACT WITH TETRAETHYL LEAD[1]

(Dosage: 0.01 c.c. of concentrated tetraethyl lead)

NUMBER OF ANIMAL	NUMBER OF DOSES	WEIGHT		LEAD PER KILO OF BODY WEIGHT
		Initial	Final	
		kilos	*kilos*	*mg.*
3	8	0.400	0.410	4.268
4	14	0.352	0.357	7.002
5	4	0.242	0.200	trace
6	13	0.370	0.344	6.104
7	20	0.360	0.377	7.294

[1] All developed tremors and convulsions before death. The autopsy findings revealed nothing.

Human Observation

Two persons who have followed the work since the beginning and who have taken precautions, knowing the poisonous nature of the compound, have stored lead as shown by an examination of the urine and feces:

In Feces	*In Urine*
mg.	*mg.*
0.76 in 24-hr. sample	0.08 in 200 c.c.
	0.14 in 200 c.c.
0.42 in 24-hr. sample	0.07 in 100 c.c.

It is interesting to observe that neither one of these persons noted any special symptoms, and in fact one of them had passed two insurance examinations within a month. They both spoke of wakefulness at night, irrational dreams, nervousness, and a general feeling of malaise which expresses itself in a general lack of "pep." Any doctor treating them and not knowing their exposure would have ascribed it to a run-down condition, needing a little tonic, etc.

Conclusions

Our experiments indicate apparently that there is no doubt that animals exposed to skin application of ethyl gasoline will store lead; also that the rate of excretion does not equal the rate of absorption. This is entirely in agreement with all medical experience. We are not prepared to say that all of the animals that died did so because of the lead. We have, however, noticed at various times that if for any reason we do not expose the animal which may appear sick for several days, the animal will show a marked improvement. This is again in line with medical experience in cases where patients have been exposed to lead. One cannot but feel, on account of this observation, that their condition before the rest was due to lead exposure. This may account for the fact that so far no cases of lead poisoning have been found at filling stations or in garages. The time between the man's exposures may be long enough to permit him to remain in apparent good health though he may be storing lead. It may take years before he stores enough or before a sufficient change takes place in his metabolism to cause the symptoms commonly attributed to lead poisoning. The fact to bear in mind is that

there is no doubt that a storage of lead takes place under exposure. Lead stored in the body constitutes a potential lead poisoning.

The same observations that have been made about animals receiving skin applications can be made on the animals that were exposed to fumes of the dilute ethyl gasoline. It is of significance that there is a continuous storage of lead taking place in the animals no matter whether it is by absorption through the skin or by inhalation. What is of special significance, or what seems so to us, is the fact that the animals in the gas chamber seem to show the effects more quickly than those which received skin applications. The dilution does not seem to make any difference except for the longer time necessary to accumulate the same quantity of lead.

FOUR CASES OF POISONING BY MONONITROCHLOROBENZENE, AND ONE BY ACETANILIDE, OCCURRING IN A CHEMICAL WORKS: WITH AN EXPLANATION OF THE TOXIC SYMPTOMS PRODUCED*

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ON MONDAY, April 30, 1923, a chemical firm started a process for obtaining, from a mixture of crude oils, two substances: ortho-mononitrochlorobenzene, an oil, and para-mononitrochlorobenzene, a crystalline body.

The workers both handled these materials and inhaled the vapor given off from the heated mixture. Three men were put on the plant. The first was admitted to Ancoats Hospital after three days' exposure; the second after three and a half days' exposure. The third was only slightly affected and did not apply for treatment.

After three and a half days the work was stopped. The weather was particularly warm during the whole of the period. The following Monday, May 7, the process was restarted, the weather was cooler, and a fresh batch of men was put on. After two days a further case occurred and was admitted to hospital. The process was continued, the men working two days at a time with an interval of fourteen to twenty-one days. On June 1, a fourth case was admitted. This was a man who had worked three shifts of two days each, and collapsed after the third.[1]

* Received for publication Aug. 1, 1925.

CLINICAL FINDINGS

CASE 1.—T., a man aged 26, had had three days' exposure. After working two days he was told that he looked yellow, but he felt perfectly well until after going to bed the third night, when he woke up feeling sick, got up to vomit, did so several times, and then suddenly collapsed. He was brought to hospital at 12:30 A.M. in a very collapsed condition, with a scarcely perceptible pulse. His face and hands were of a peculiar slate-gray and cyanotic appearance; this was especially noticeable in the lips, conjunctivae, and nails. He was sufficiently conscious to complain of pain and throbbing in his head and in the back of his neck, and of pain in the upper abdomen. His breath smelt strongly of oil of bitter almonds; this odor was perceptible some distance from the patient.

Physical Examination.—The heart, lungs, and abdomen on examination were normal. The knee jerks were present and

[1] The authors are indebted to Dr. A. H. Holmes for access to these cases, and to Mr. T. H. Fairbrother for his assistance.

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the pupils were equal and reacted normally. There was no dyspnea. The patient was given an emetic (Atropine Sulph. gr. 1/50), oxygen, and stimulants (*viz.*, ether, pituitary extract, and a coffee enema). The following morning he had recovered from his collapse. The temperature was 101°; the pulse and respirations were normal. There were subconjunctival hemorrhages in both eyes and the slate-gray appearance was unchanged. The temperature was normal within twenty-four hours and remained so during his stay of fourteen days in hospital. There was no jaundice at any stage.

After two or three days in bed there was no improvement in color and the patient became dyspneic on the slightest exertion. From this time he made a gradual recovery, the color fading and the dyspnea growing less.

On discharge he was distinctly gray in appearance. He was in hospital May 3 to 17, 1923.

Laboratory Findings.—The urine was normal throughout. Several blood examinations were made and the results are given in Table 1. The blood serum was of a port wine color. On May 4, 1923, the van den Bergh reaction was negative.

Case 2.—G., a man aged 27 years, was inpatient from May 3 to 12, 1923. He had suffered three and a half days' exposure. He felt pain and throbbing in the head about midday; he took his midday meal with some alcoholic drink and collapsed soon after. He described his sensation as that of inability to walk and weakness in the legs. His general state was much better than that of Case 1. There was the same peculiar cyanotic appearance. A similar odor of bitter almonds was noticed in the breath. Treatment similar to that in Case 1 was given.

Physical Examination.—Physical examination was negative. A dyspnea on exertion similar to that of Case 1 was noted after two or three days.

Laboratory Findings.—The urine was normal. The van den Bergh reaction was negative.

Case 3.—C. was inpatient from May 8 to 12, 1923, having had two days' exposure. He noticed pain and throbbing in the head on the evening of the second day, when he fainted and was brought to hospital. His general condition was quite good, and there was very little collapse. The typical odor, slate-gray color, and dyspnea were present. He was treated in a manner similar to Cases 1 and 2. He came under observation, however, somewhat earlier than the other cases. It was noticed that after admission his dusky appearance deepened considerably; then after twelve hours or so, he started to improve gradually.

Physical Examination.—Physical examination was negative.

Laboratory Findings.—The urine was normal. The van den Bergh reaction was negative.

Case 4.—E., a man aged 35 years, was inpatient from June 1 to 9, 1923. He had three exposures of two days each, and collapsed at the end of the third exposure. On admission he was comatose and profoundly collapsed. The typical color and odor were present.

Physical Examination.—Radial pulse had failed. The breathing was feeble. The pupils were equal and reacted normally. The knee jerks were present. There was nothing abnormal found in the heart, lungs, or abdomen. Dyspnea developed later.

Laboratory Findings.—Urine was normal. The van den Bergh test was negative.

Investigation of the Process

Mononitrochlorobenzene is chlorobenzene which has been nitrated. A certain amount of nitrous fumes is liberated during its manufacture, but no other volatile intermediate products. These fumes are carried up a chimney and so do not reach the men affected by the process. This nitration is carried out in large tanks from which the oil is run at a temperature of about 90°C. into large, shallow, open rectangular trays where it is allowed to cool.

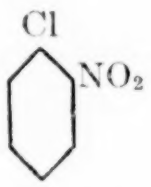
The para-mononitrochlorobenzene crystallizes out from a supernatant oil—ortho-nitrochlorobenzene—which

TABLE 1.—RESULTS OF BLOOD COUNTS IN FOUR CASES OF POISONING BY MONONITROCHLOROBENZENE IN A CHEMICAL PLANT

CASE NUMBER	DAYS AFTER EXPOSURE	RED BLOOD CELLS	HEMOGLOBIN	COLOR INDEX	WHITE BLOOD CELLS	REMARKS
		per c. mm.	%		*per c. mm.*	
1	1	4,460,000	80	0.9	12,000	Some red blood cells are fairly large and show modified polychromatophilia; some are distorted.
	2	4,270,000	80	0.94	.....	.....
	4	3,630,000	72	1.0	.....	.....
	6	3,630,000	65	0.97	.....	.....
	12	3,100,000	68	1.09	.....	.....
	14	3,300,000	66	1.0	.....	.....
	26	4,230,000	86	1.02	.....	Majority of red blood cells are well formed, a few slightly crenated. No punctate basophilia. Cells appear to contain considerable hemoglobin.
	40	4,640,000	102	1.1	.....	Red blood cells appear normal in size and shape. No nucleated red blood cells.
2	1	4,440,000	95	1.08	8,400	No punctate basophilia; shape in general good, but some red blood cells look as if a bite had been taken out of them.
	2	4,950,000	102	1.03	.....	.....
	4	4,550,000	96	1.05	.....	.....
	6	4,990,000	100	1.01	.....	.....
	26	5,500,000	100	1.1	.....	The majority of red blood cells are well formed. No punctate basophilia. Cells appear to contain a considerable amount of hemoglobin.
	39	4,460,000	98	1.1	.....	Cells appear practically normal. A few rather small red cells present; and a few crenated. Staining good. No nucleated red blood corpuscles.
3	2	6,030,000	112	0.93	20,200	In this film some red blood cells are definitely crenated. Bite forms not present. No punctate basophilia. A few cells show moderate amount of polychromasia. Size is fairly uniform but there are a few rather large red blood cells.
	21	5,380,000	110	1.02	.....	Cells appear to be of good shape, a few are approximating to size of megalocytes. No punctate basophilia.
	35	5,590,000	106	0.95	.....	Red blood cells appear normal in size and shape. No nucleated red cells.
4	3	5,630,000	100	0.89	9,800	Red blood cells are fairly well formed; a few microcytes; one or two cells occur with appearance of bite taken out. No punctate basophilia.
	5	5,950,000	96	0.8	.....	.....
	7	5,130,000	90	0.88	.....	.....
	11	4,890,000	86	0.88	.....	.....

is subsequently run off into drums, and the para-mononitrochlorobenzene is then shoveled up into barrows, taken to a centrifugal machine to be dried, and carried away to be stored in casks.

para-mononitrochlorobenzene



ortho-mononitrochlorobenzene

The men who are affected are the men who attend to the trays, and an exposure of only one day has resulted in serious illness. As a rule three days' exposure is required. The condition appears to affect workmen who take alcohol (beer) more than it affects teetotalers, although there is one exception to this rule, in the person of one Irish workman who is known to imbibe freely. Fat men are more markedly affected than thin individuals.

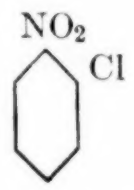
The mononitrochlorobenzene which is produced has a boiling point of 243°C. for the ortho variety, and one of 242°C. for the para compound. No temperature approximating to this is reached during the process.

There is a distinct odor coming from the pans of the finished product during cooling and after the oil has been run off; as a large surface is exposed (roughly a quarter of the total area of the lungs), it would appear possible that during the day a fairly considerable amount of vapor may be given off from the trays and absorbed by the lungs. Great care was taken to avoid absorption from the skin by causing the workmen to wear India-rubber gloves, thigh boots, and aprons, to change their clothes, and to take a bath before going home. As cases still occurred, it appears probable that the vapor is absorbed through the lungs.

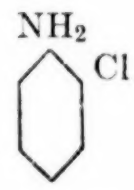
The only other mode of entrance might be through absorption of vapor by the mouth and consequent absorption by the alimentary canal; but it appears to us that the pulmonary route is the more probable. (See under Preventive Methods where reference is made to manufacture in Switzerland.)

Aniline the Probable Toxic Agent

Mononitrochlorobenzene on reduction is converted into amidochlorobenzene (chloroaniline), which is highly toxic and a very reactive substance. It is possible that on absorption into the blood mononitrochlorobenzene is slowly converted into amidochlorobenzene by the reducing action of hemoglobin, 2 oxygen atoms being replaced by 2 hydrogen atoms, since venous blood brought to the lungs would tend to reduce the compound; or in the tissues after the



mononitrochlorobenzene



chloroaniline

hemoglobin has given up its oxygen to the tissues, a reducing action of the hemoglobin, or of the tissues themselves, on the nitrochlorobenzene might be present. Here also the detoxicating action of the liver cells may play a part, and this may explain why an alcoholic subject is more liable to toxic effects than is a total abstainer, the liver cells being more probably not damaged in the latter by cirrhosis or fatty change. Thus Rambousek[2] mentions an instance in which four chlorobenzene workers were found unconscious after a bout of drinking and recovered only after eight to ten hours in hospital. The symptoms were a "grey-blue colour of the skin, pallor of mucous membranes, lips, nose, and conjunctivae, and peculiar chocolate-coloured blood." Before referring to Rambousek's cases we had also noted the peculiar chocolate-colored blood in our cases, and had referred to it as such. This color makes a definite change in the appearance of the blood and is probably due to the formation of methemoglobin, although the possibility of formation of acid hematin should also be considered. The gradual formation of this more stable hemoglobin compound with oxygen causes the dyspnea and cyanosis and also accounts for the latent period between exposure to poisoning and onset of symptoms, and the cumulative nature of the intoxication.

One Case of Acetanilide Poisoning

This explanation would bring into line the exactly similar symptoms met with in the case of acetanilide poisoning here also recorded. Aniline, it may be said, is so poisonous that, it is stated, if a surface the size of half a crown be covered with aniline oil, toxic symptoms may occur. The particular workman involved in this case was crushing acetanilide for the manufacture of para-nitraniline. He was continuously employed in breaking up and putting acetanilide, which is first made, into a crushing machine. After going through the crushing machine, the powdered acetanilide was removed by the same man, from a hopper, and in this process the man must of necessity inhale or even ingest by mouth a fairly considerable amount of the dust. His hands also were covered with the powder. The acetanilide used may contain free aniline to the extent of 0.1 to 0.2 per cent.; it is probable, therefore, that the toxic effects in this case arose again from absorption of the aniline present as an impurity in the acetanilide. No chloroaniline is produced in any part of the process of the manufacture of para-nitraniline, so that such explanation is necessary to account for and fully explain the presence of the free aniline, since in the course of a day one man handles a large amount (several barrowfuls) of the powdered acetanilide. In this condition the aniline is again probably the toxic molecule.

Preventive Methods Suggested

We discussed with the manager of the works and the chief works' chemists the steps which might be taken to guard against further cases of what is undoubtedly a dangerous and most severe form of poisoning arising from

[2] Rambousek, J.: Industrial Poisoning from Fumes, Gases and Poisons of Manufacturing Processes. London, Edward Arnold, 1923, pp. 115–116.

industrial work in connection with the manufacture of mononitrochlorobenzene. We suggested that, since skin absorption appears to have been guarded against and this precaution proved of no avail, steps should be taken to guard against the inhalation of any vapor arising from the trays during the cooling process and afterward during the collection of the finished product. A simple measure would be the covering of the trays with doors or wooden lids during the cooling process, with, if need be, the employment of suction to remove any vapor from the trays. We pointed out the importance—if the trays are covered—of avoiding the inhalation of concentrated vapor which might result from the covering of the trays without adequate removal of collected vapors; if no such removal of vapor from the closed trays is employed, great care should be taken when the trays are first uncovered after cooling not to allow the men to inhale the concentrated vapor.

The employment of gas masks might be beneficial.

In Switzerland

We are informed that in Switzerland where this firm has another works, cases are more common even than in England, and this prevalence is attributed to the fact that the continental workman cannot stand so much as the British laborer. It appears to us, however, that a question of altitude may be involved, and that in the rarer atmosphere of Switzerland respiration is proceeding more rapidly and freely, so that in any given time there will be a greater percentage of poisonous vapor inhaled. Furthermore, symptoms of asphyxia will be more readily met with in a higher altitude if there is any toxic substance acting on the hemoglobin of the blood. Gas masks should be used by the workmen.

Conclusions

Observation of these cases has led us to the conclusion that mononitrochlorobenzene is a poison affecting chiefly the blood, as is also the case with other nitrobenzene compounds. Its effect is cumulative; and when a sufficient quantity has been absorbed, toxic effects may occur which are hastened in some cases by a meal or by alcoholic drinks. Toxic effects may be delayed owing to the gradual action on the hemoglobin of the blood. Thus all the cases dealt with by us collapsed some hours after leaving work. The cyanosis and collapse appeared to progress to a maximum, after which gradual recovery extending over some weeks occurred. The dyspnea on exertion seemed to develop in each case a day or two later and to correspond with the period of the lowest red cell count; as the patient's dyspnea and cyanosis disappeared, the blood picture approximated more and more to the normal.

In this type of poisoning we have an initial collapse, a typical color, and a delayed anemia with a high color index. There is no jaundice, and no nucleated red cells were seen in any film. Some red cell distortion and a few small forms are the only changes noted. The white cells are not affected.

These effects could be explained by supposing that after absorption the poison combines with the hemoglobin in the red blood cells, producing a

stable compound which impairs the oxygen carrying power of the blood—the amount of collapse and the danger to life being directly proportional to this impairment and due to oxygen deficiency. The absence of marked poikilocytosis and the total absence of jaundice, together with the high color index, make it evident that the anemia is not due to excessive blood cell destruction.

The late development of the anemia and the absence of the nucleated red blood cells and of megaloblasts suggest that the anemia is due to a profound depression of the activity of the blood forming organs—*viz.*, the bone marrow—so that fewer cells are produced but each containing a higher percentage of hemoglobin; hence the high color index. The effects, therefore, of mononitrochlorobenzene poisoning are twofold:

1. The formation of some stable compound with the hemoglobin gives rise to the peculiar cyanotic appearance and the collapse from oxygen deficiency.

2. Profound depression of the activity of the bone marrow results in a delayed anemia with dyspnea on exertion.

PROPHYLAXIS IN INDUSTRIAL LEAD POISONING*

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CASES of lead poisoning still occur in considerable numbers in spite of codes of regulations applying to lead industries. The mode of poisoning is now generally attributed to the inhalation of dust or fumes, although other ways cannot be wholly excluded. According to Oliver (1) these dusts or fumes enter the system mainly by the alimentary tract: "Admitting that the lungs and the respiratory passages are frequent channels of entrance of lead into the system, I am of opinion that it is by the alimentary canal, even when lead has primarily reached the upper part of the respiratory passages, that most of the poison enters the body. Reaching the stomach, it is acted upon by the hydrochloric acid of the gastric juice, whereby it is rendered soluble, and is absorbed unless proteid food is being digested at the same time, when only minute quantities of lead will be absorbed, the bulk of the poison being thrown out in the faeces."

The problem, therefore, is to prevent access of dust or fumes to the air passages and mouth; failing in this task, it will be necessary to pursue the poison through the alimentary tract, with the aim of neutralizing it there. Locally applied exhaust ventilation, so as to remove dust and fumes at the point of origin, is the leading condition recommended by the General Conference of the International Labour Organisation held at Washington in 1919, and now adopted in Great Britain, before permitting the employment of women and young persons. Even when such ventilation is in use, continuous efficiency is the exception rather than the rule. Maintenance of efficiency demands ceaseless supervision and vigilance, and their correlative, expense. Even good schemes tend to be run slackly, after a while.

Such being the state of the case, the second means still remains to be applied. The various advices given on Home Office Form 406 (2) are very valuable, stressing as they do the avoidance of raising dust; scrupulous cleanliness of hands, face, teeth, and clothing; mouth-washing; and the need for an albuminous meal before starting work. General advice to the worker to take "aperient medicine, such as Epsom salts (one or two teaspoonfuls in water) . . . . once or twice a week" is also given. It is very disappointing to observe that this tabloid wisdom of Sir Thomas Legge is so generally ignored or perfunctorily performed. The Scottish national poet, Burns, has rhymed it thus:

> The fear o' hell's a hangman's whip,
> Tae haud the wretch in order.

* Received for publication Aug. 22, 1925.

In these times, however, the Home Office does not seem able to inspire any such fear into master or man, even though health is at stake. To all such recommendations, the almost invariable response is that of Shylock, "Is it so nominated in the bond?" Thus the washing provisions are of a type which does not appeal to the younger workers, who have seen much better facilities in the local education authority schools. Instead of a range of, say, half a dozen hand basins of modern design, there is usually a square deep sink, with a single tap. The result is that the workers have to line up for the performance, and there is every inducement for them to scamp the proper washing of the hands. Then the hot water is limited, while the soap, the nailbrush, and the towel are frequently of the Barmecidal order. And there is the usual explanation, namely, that these articles are supplied, but they disappear. With regard to the Epsom salts, the working foreman often has a bottle to which he adds a variable quantity of salts from time to time, and a glass to be used in taking a draft. These are kept in a working office and their dusty condition raises the question whether their use is not rather more a danger than a help.

Observations such as these lead us to ask: If the use of lead is not to be abolished, is it not time that the carrying out of these recommendations in a thoroughly efficient manner should be made compulsory, part of the ritual of the day's work, and placed under the management of a member of the executive staff? Thus, at a specified time before cessation of work for meals or at the end of the day, the men should assemble in the washing room and carry out the washing under the eye of an "officer" from the administrative department, whose duty it would be to see that everything was in readiness for these times. He would also see to proper mouth-washing and would have the suitable solutions ready for immediate distribution in clean vessels. In this regard, I venture to suggest a solution which I consider would be of value for repeated use, and would probably not prove so obnoxious as those made in a haphazard manner. Of course, it is only a prophylactic and will not infallibly prevent lead poisoning. Its composition and use are based on two fundamental propositions: (1) that given above, which may be called Oliver's —namely, that the poison enters the body mainly by the alimentary passages; and (2) that which may be called Legge's—namely, "Somewhere about 2 milligrammes (or 0.002 gramme) of lead is the lowest daily dose which, inhaled as fume or dust, may, in the course of years set up chronic plumbism. Probably if the air breathed contains less than 5 milligrammes per 10 cubic metres of air, cases of encephalopathy would never, and cases of colic very rarely, occur. And this is a quite practical figure to keep the dust down to in any process amenable to exhaust ventilation" (3). Ten cubic meters measures the total quantity of air which passes into (and out of) the lungs of an adult, *at rest*, breathing 500 c.c. per inspiration and 14 inspirations per minute. This quantity is increased, and may be more than doubled, by exertion (4).

From the first proposition the deduc-

	Stock Solution (Winchester Qt. = 80 oz.)	*Drinking Solution* (Winchester Qt.: add 1 oz. stock) contains	*Dose of Drinking Solution* 2 oz. contains	*Equivalent of Dose in Lead Carbonate*
Epsom salts ($MgSO_4 \cdot 7\ H_2O$)....	8 oz.	40 gr.	1 gr.	70 mg.
Glauber's salts ($Na_2SO_4 \cdot 10\ H_2O$)	16 oz.	80 gr.	2 gr.	100 mg.
Aromatic sulphuric acid (B. P.).	$1\frac{3}{4}$ fl.℥	10 ♏	$\frac{1}{4}$♏	5 mg.

tion is made that while the mouth and teeth should be carefully cleansed and any soluble lead precipitated, such soluble lead as may have been swallowed in the saliva and pharyngeal secretions, and even postnasal excretions, should be, if possible, precipitated in the stomach. This can probably be accomplished if a suitable dose of soluble sulphate is given on the empty stomach. It is therefore advised that the proposed solution should be used in such an amount that approximately half of the quantity provided at each mouth-washing be used for such purpose, and, thereafter, the remainder be swallowed into the stomach.

The second proposition gives a clue to the minimal amount of lead that has to be rendered inert—namely, 2 mg. From the respective chemical equivalents, it can be readily calculated that 1 mg. ($\frac{1}{64}$ grain) of white lead ($2\ PbCO_3 \cdot Pb(OH)_2$) requires for its complete precipitation as lead sulphate approximately the following amounts of:

Magnesium sulphate	0.95 mg. (about 1/70 gr.)
Sodium sulphate	1.25 mg. (about 1/50 gr.)
Sulphuric acid	0.38 mg. (about 1/170 gr.)
Aromatic sulphuric acid (B.P.) (13.8 gm. per 100 gm.)	0.003 c.c. (about 1/20 ♏)

Imitating Nature's methods, it is advisable to give as large an antidotal dose as is compatible with pleasantness in the mouth and wholesomeness to the stomach. From various trial solutions, the foregoing was selected as satisfying the conditions laid down. There is no reason why the proportions of the ingredients should not be varied in either direction. It is an open question whether to give the solution a distinctive color or not.

An important point to note is that, even should a mistake be made and the stock solution used instead of the drinking solution, the amounts of all the ingredients are still within the limits of the ordinary doses prescribed in the British Pharmacopeia, and are well diluted, so that no harm would ensue, in such a case, further than the production of an unpleasant taste. From this point of view it might be advisable to color the stock solution. In that case, no other colored solutions should be kept near it which might cause further confusion of a dangerous kind.

The sulphuric acid is added to activate the solution. The equivalent of each dose in lead carbonate is shown as 175 mg., approximately one-half of which is expended on the mouth, and

the other half on the stomach. There is thus a large surplus of safety for small doses of lead infection.

It is recommended that the solution should be used at all cessations from work, which would be two or three times a day. The solutions should be kept in a dust proof cupboard and under the supervision and control of the administrative officer already designated. The cost of the stock solution is trifling—about 1s. 6d., or 40 cents, wholesale per Winchester Quart bottle, and this amount would serve five men twice a day for a year of fifty-two weeks.

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THE ORGANIZATION AND OPERATION OF AN INDUSTRIAL HEALTH DEPARTMENT: A DESCRIPTION OF THE WORK OF THE DEPARTMENT OF HEALTH OF THE TENNESSEE COAL, IRON AND RAILROAD COMPANY*

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WITHIN the last few years many articles have been published dealing with the various phases of industrial welfare work. Many of these articles have been based purely on theory, while some have been descriptive of excellent work already in progress but not of very wide scope.

I have the honor to present for your consideration a brief description of the organization and work of the health department of the Tennessee Coal, Iron and Railroad Company, the function of which is, in broad terms, the maintenance of health and working efficiency of all employees of the Company.

The Tennessee Coal, Iron and Railroad Company, a subsidiary of the United States Steel Corporation, is engaged in the operation of iron ore mines, coal mines, quarries, blast furnaces, and various plants for the manufacture of steel. These mines and plants are distributed over a wide territory, although most of them are within a 15-mile radius of Birmingham, Ala. The Company averages on its payroll about 23,000 men, 57 per cent. of whom are negroes and 40 per cent. whites, only 3 per cent. being foreign born. From 40 to 50 per cent. of these employees live in villages owned by the Company, which are contiguous to mines and plants. The remainder of the force live in the city of Birmingham proper, or in villages and towns within short distances of the plants in which they are employed. Twenty-two separate and distinct villages are owned and entirely maintained by the Company, the Company being responsible for everything ordinarily handled by a municipality.

Many of these villages were constructed by the Company a number of years ago without giving much consideration to the type of houses built, or to their arrangement or location. Since the Company was acquired by the United States Steel Corporation in 1907, however, much attention has been given to proper house construction, and much remodeling and rearranging has been done in the old villages (see Figs. 1 and 2); in the more modern villages, the houses have been well planned and located. The houses of the modern groups are of three, four, and five room type, with running water at every house, and with ample

* Read before the Tenth Annual Meeting of the American Association of Industrial Physicians and Surgeons in Atlantic City, May 25–26, 1925. Received for publication Aug. 20, 1925.

yard and garden space. Attention has also been given to variation in type of construction and variety in painting the houses. In addition to

FIG. 1.—Alley scene before United States Steel Corporation control of Tennessee Coal, Iron and Railroad Company.

houses for employees, these villages contain commissaries, bathhouses, schools, churches, and clubhouses, constructed by the Company.

Prior to 1913, the sanitation of these villages was, generally speaking, in the hands of the local superintendent, with no supervision by a skilled sanitarian beyond some attention to water supplies. The medical work for the men and their families, as well as the handling of injury cases, was done under the old "contract" system, the physician being engaged by the local or general superintendent, and receiving a certain amount per man for his work, the collection of this fee being made from the men through the payroll. A number of physicians were employed on this basis, and each one was entirely independent of his fellows. Under the usual contract, the physician was supposed to furnish the necessary medicine and hospital care at his own expense, and to employ the necessary number of assistants to do the work. The natural consequence of this practice was that usually the work was done as cheaply as possible and consequently unsatisfactorily.

FIG. 2.—Typical alley under present conditions.

Early in 1913 the department of health of the Company was organized, a superintendent and assistant superintendent of the department engaged, and the department organized on a basis similar to that of other operating departments of the Company. For convenience the department functions in four divisions: sanitary, medical, dental, and base hospital.

SANITARY DIVISION

The sanitary division, under the direction of a chief sanitary inspector, is responsible for the following: the purity of all water supplies; the care of closets and disposal of fecal matter; the collection and disposal of trash and garbage; the cleaning and draining of streets and alleys, including weed and grass cutting; the supervision of house premises; the inspection of all places where work is done; the elimination of mosquitoes; the inspection of stables and the prompt disposal of stable manure for fly prevention; the isolation and quarantine of cases of com-

municable disease; the supervision of milk supplies and the inspection of all commissaries to insure proper protection and purity of food supplies.

The twenty-two villages of the Company are divided into six sanitary districts, each under the charge of a sanitary inspector, who has a sufficient force under his immediate direction to carry on all phases of the work. Sanitary inspectors report directly to the chief sanitary inspector, who in turn reports to the head of the department. The sanitation of these districts involves so many items that it is impossible to go into all details in the time allowed; therefore, only a few of the more important will be touched upon.

Water Supplies.—Wherever it is possible to do so, our villages are supplied from the municipal water supply of the city of Birmingham, which is ample and of excellent quality. Where this is impossible, filtration plants or treating plants have been constructed. A most careful check is kept on all water supplies, specimens being examined at our general laboratory at frequent intervals.

Care of Closets.—The average life of a mining town is too short to justify the great expense of a general sewerage system, and, in addition to this, the question of final disposal and of water expense has had to be considered. We, therefore, adopted the pail system in our villages (see Fig. 3), and closets are constructed with a view to adequate ventilation and proper fly protection. Pails are removed and clean pails replaced at least twice each week. Final disposal is accomplished by means of disposal plants, constructed for the purpose after a considerable amount of experimentation in the handling of concentrated fecal matter. All of our permanent manufacturing plants are equipped with water-borne sewerage, some of which

FIG. 3.—Method of handling and transporting pails for feces disposal.

is disposed of through the city sewers, and some handled in especially constructed disposal plants. Throughout the manufacturing plants, the toilets constructed for workmen are generally equipped with the "floor type" bowl, which we have found satisfactory in every respect.

Garbage Disposal.—Garbage collection is made daily. Each house is equipped with a covered receptacle, stationed at the rear gateway on the alley. Final disposal is accomplished by incineration in a type of plant designed by us for the purpose. This is satisfactory and economical.

Mosquito Control.—Mosquito breeding is general throughout the Birmingham District from the middle of April to the middle of October, and malaria has not only caused many deaths and much illness, but has seriously interfered with the efficiency of labor in the past. A careful survey made in 1912 listed in excess of 8,000 cases of malaria among employees and their families, either in or around our vil-

lages. The accompanying chart (Fig. 4) shows the reduction that has been accomplished by careful drainage of pools and swamps where this could be done, the straightening and cleaning

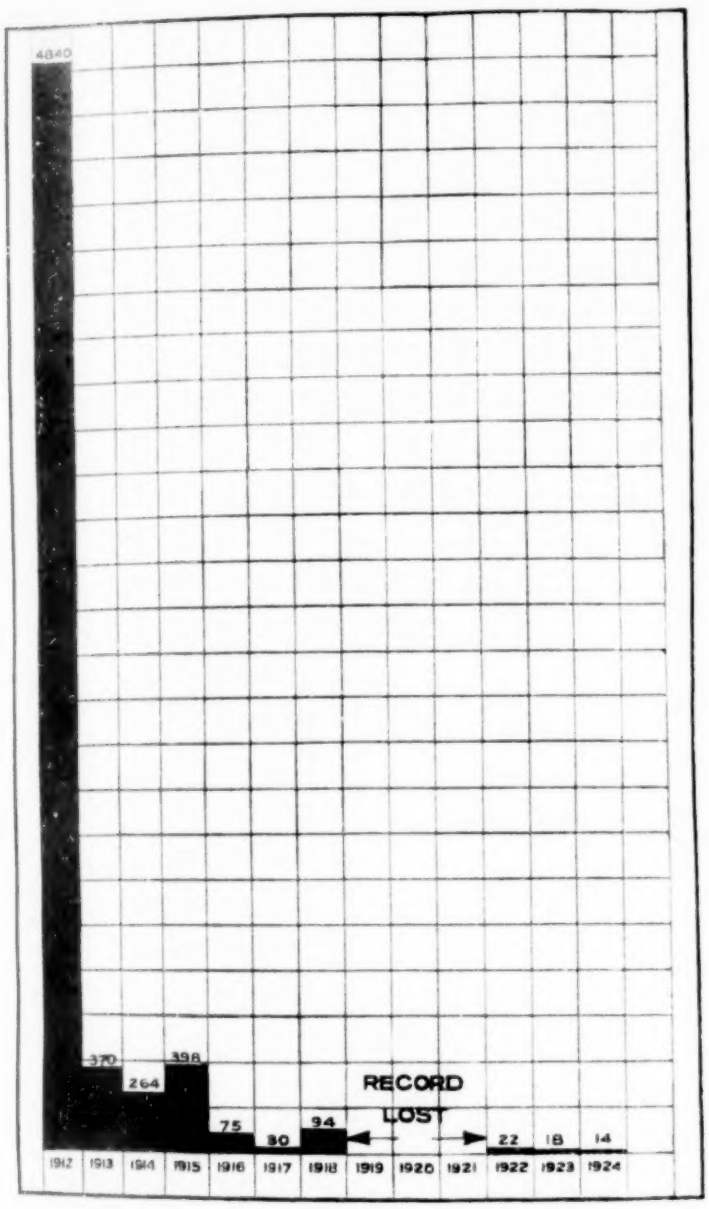

FIG. 4.—Malaria incidence by years, 1912 to 1924, in the villages of Tennessee Coal, Iron and Railroad Company.

of streams, with care of banks and removal of water growth where necessary; the planting and cultivation of top minnows (*Gambusia*) in impounded water supplies; the use of larvicide in smaller collections of water, and some oiling. At present our villages are practically mosquito free, and malaria has become one of the least of our problems.

Fly Protection.—Stable manure is, of course, the great fly incubator, though wet trash and garbage also play a part. All stables have been properly floored with concrete, with oak inlay in the stalls. Each stable is equipped with water pipes and hose

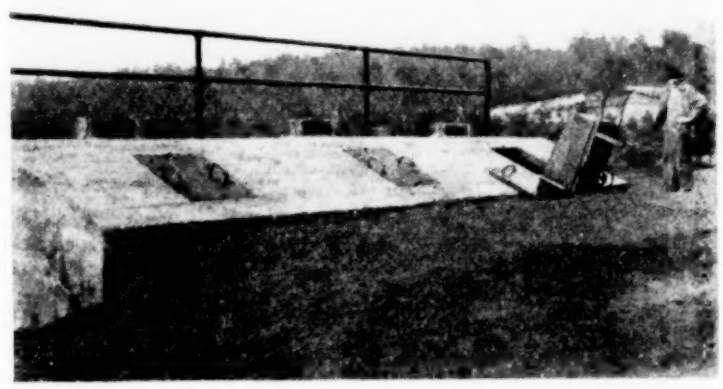

FIG. 5.—Manure destruction pit (front view) for fly control.

connection for flush, and the rule is absolute that each stable must be cleaned thoroughly at least once each day. In the early part of our work we incinerated all manure, but we found that this material was in great demand for fertilizing purposes, as the Company encourages employees in every way to cultivate gardens. After long study of the problem and investigation of many theories, the Kibbey manure bin was designed by our chief sanitary inspector, C. H. Kibbey, and has been installed at all stables (see Fig. 5). This bin, in brief, provides for the fermentation of manure under fly proof conditions. The eggs, which have been deposited before the manure is placed in the bin, are hatched there and the flies are caught in the traps provided. It is thoroughly proved that manure which has undergone primary fermentation will not hatch flies when removed from the bin. The interval required for treatment is about forty days, after which the manure is removed from the bin and

is used as fertilizer without fly hazard.

Food and Milk Supplies.—The Company maintains in each of its villages a modern and well-equipped store or commissary. The most careful attention is paid to the purchase and sale of good food supplies, and to the protection of these supplies in handling. Commissaries are under daily inspection by the sanitary inspector, and employees who handle food supplies undergo physical examinations at regular periods. The quality of milk sold at the commissaries and the method of handling it are also carefully regulated.

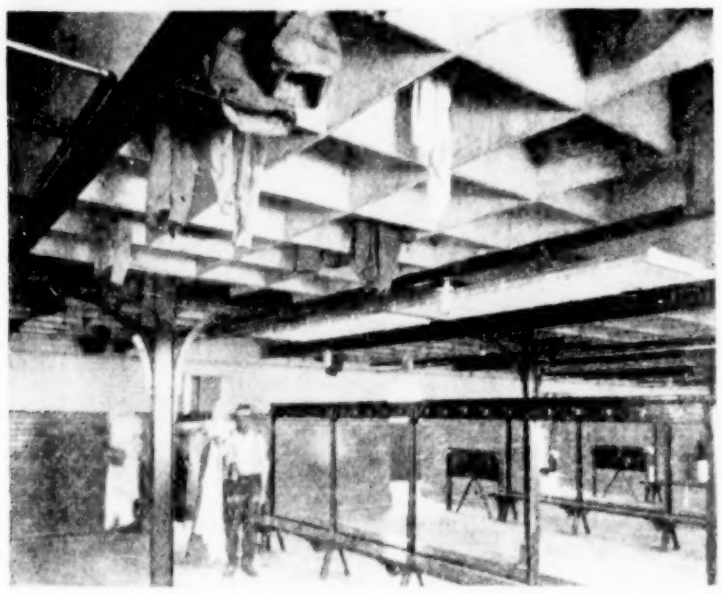

FIG. 6.—Interior bathhouse for colored employees, showing suspended open box lockers.

Bathhouses.—In conjunction with operating the departments, a great deal of attention has been given to the construction and maintenance of bath or change houses, which have been installed at practically all works and mines. It has been our aim to secure a high degree of efficiency without elaborate expenditure for construction of buildings or equipment. We have gradually progressed from the standard locker arrangement, through the German hanger arrangement, to a system of suspended open boxes which prevent contact of different men's clothing (see Fig. 6). This system is highly satisfactory in securing rapid drying and good ventilation and in preventing the accumulation of ill-smelling and useless material.

MEDICAL DIVISION

The medical division is charged with the operation of seventeen dispensaries and emergency hospitals at our various works and villages. The force consists of forty-six doctors, who devote their entire time to this work.

Distribution of Medical Force.—This force is distributed as follows:

Ensley Division.—One district physician and six assistants.

Fairfield Division.—One district physician and six assistants.

Pratt Division.—One district physician and three assistants.

Wylam Division.—One district physician and three assistants.

Edgewater Division.—One district physician and two assistants.

Bayview Division.—One district physician and two assistants.

Bessemer Division.—One district physician and two assistants.

Docena Division.—One district physician and one assistant.

Muscoda Division.—One district physician and two assistants.

Wenonah Division.—One district physician and one assistant.

Ishkooda Division.—One district physician and one assistant.

Greeley Division.—One district physician.

Ketona Division.—One district physician.

Vanns Quarry Division.—One district physician.

Oxmoor Division.—One district physician.

Blocton Division.—One district physician.

Whitwell Division.—One district physician.

In addition to the medical work, district physicians act as local health officers, co-operating closely with the sanitary service in the handling of communicable disease.

Functions.—The medical division undertakes the handling of emergency accident cases occurring in line of duty, as well as the general medical care of all employees and their dependent families residing within a radius of $2\frac{1}{2}$ miles of each dispensary, treating employees and their families either at the dispensaries or at their homes, as necessary. The physicians of the medical division are also charged with the physical examination of all workmen before employment, and with the physical examination of schoolchildren.

Expense.—The expense of the medical division is borne partly by the Company and partly by the employees, through a system of a voluntary contribution. Under this system, any employee living within a certain radius of the works and mines may request that he be placed on the "medical list." The payment of $1.25 a month entitles each employee and his dependents to treatment for any possible ailment, either at the dispensaries or at his home, also to professional service at the base hospital. At present practically all employees living in the zone of this service voluntarily avail themselves of its advantages.

Physicians are employed on a straight salary basis, and also receive compensation for automobile expense.

Examination of Employees.—The dispensaries are well constructed and well equipped for diagnostic and treatment work, and the service is extremely popular with employees. During the year 1924, 206,223 patients were treated at dispensaries and 92,032 calls were made at the homes of employees; also, 26,252 examinations of new or reemployed men were made. We regard the physical examination of workmen before employment as extremely important. Under this system, every new employee is carefully examined before employment, and any employee who has been absent for as long as fifteen days for any cause is reexamined before he is returned to employment. In this way the vast majority of employees are examined at least once yearly. Men who are a danger to themselves or to their fellow workmen are eliminated. Those with physical defects are discovered and properly treated, or assigned to work which is suitable for them. Men who are suffering with communicable disease are discovered and properly treated.

Pediatric Clinics.—Pediatric clinics are held in each village for both white and colored children at least once a week by a skilled pediatrician, who keeps in close touch with the medical force of the district, and with the social science department. Follow-up work is done by the social workers. These clinics are extremely popular, and a great reduction in infant mortality has been accomplished.

Dental Division

Eight dental clinics are maintained, one at the base hospital and seven at the larger dispensaries. All classes of work are undertaken. Employees are treated at a very low rate, sufficient only to cover actual operating cost. This dental service is extremely popu-

lar, and we expect gradually to extend it to cover all dispensaries. At present fourteen dentists constitute the force and they find it impossible to do more than 50 per cent. of the work brought to them. These dentists are employed on a straight salary basis, as are the physicians. One dentist is engaged exclusively in school work. During the school term his traveling outfit is set up at each school in rotation, where he remains until every child in the school has been examined and properly treated.

Hospital Division

The base hospital at Fairfield, Ala., is the clearing house and center of all of the work of the department. This hospital is situated as closely as possible in the center of the various works and mines of the Company. It is a modern building of brick, reenforced concrete, and terra cotta, with a capacity for 310 patients of all classes; it is completely equipped in every respect and has a fixed staff of nineteen physicians, covering the various specialties.

Outpatient clinics are maintained, to which cases are constantly referred by the various district physicians and their assistants, these clinics acting as a basis of consultation work with outside men. Any employee or member of his dependent family is eligible for treatment, professional service being provided for through the "medical list" previously referred to, the hospital expense being furnished at an extremely low rate. Provision is made in the hospital for every type of case: medical, surgical, genito-urinary, orthopedic, pediatric, obstetric, X-ray, dental, electrotherapeutic, etc. We consider this hospital one of the finest of its kind in the country, and are proud of the work that is accomplished there. The hospital is practically always full, and usually there is a waiting list of elective cases. Accommodations consist of wards, of semiprivate and private rooms at moderate cost, and of a few private rooms equipped for patients desiring the best that can be obtained.

Training schools for both white and negro nurses are maintained at the hospital. At present there are thirty-two white pupil nurses and thirty-seven negro pupil nurses enrolled.

The hospital staff consists of the following: chief of surgical clinic, with two assistants; chief of medical clinic, with two assistants; chief of eye, ear, nose, and throat service, with one assistant; a radiologist, with three technicians; a chief of laboratory, with two technicians; two dental surgeons; visiting consultants in eye diseases, orthopedics, genito-urinary diseases, pediatrics, and obstetrics; ten interns; the graduate nurse staff, which consists of a superintendent of nurses, an assistant superintendent of nurses, and fourteen supervising nurses.

Social Science Department

The social science department of the Company, operated as a separate department, has charge of excellent schools in each village. These schools are run through a system of cooperation with the county board of education. Under this system the social science department is at present operating eight white schools and fourteen schools for negroes, with a total enrollment of 5,494 children. In addition to this, the department operates schools of instruction for

cooking and sewing, kindergartens, clubhouses in the various villages, bathhouses for women and children, school gardens and supervised play of all sorts.

In co-operation with the department of health, careful physical examinations are made on schoolchildren each year. Defective children are cared for between the two departments by a follow-up system conducted by the social workers. The social workers co-operate closely with the pediatric clinics maintained in each village.

Conclusion

The organization of the department of health as outlined has grown from practically nothing in 1913 to its present size. It forms a compact organization covering the care of employees from the beginning of employment to old age, and of their families from birth onward through life. It enables a class of people, ordinarily neglected and usually greatly imposed upon, to secure the benefits of careful sanitation, excellent medical treatment, and the best of hospital service at a rate within the reach of all. While the expense involved is, of course, very large, it is felt that the benefits accruing to the Company are even larger. The working force is apparently deeply appreciative of what is done for them, they feel that they are bearing a fair proportion of the expense, and we believe that it would be hard to find a more completely satisfied group of workmen anywhere in the world.

In conclusion I wish to quote an opinion as to the value of the work just described which was recently expressed by Mr. George Gordon Crawford, President of the Tennessee Coal, Iron and Railroad Company, whose sympathy and broad understanding has had much to do with its success:

> The Tennessee Coal, Iron and Railroad Company has 383 employees who give full time service in connection with the Health Department of the Company.
>
> The Health Department's activities, comprising surgical, medical and sanitary work, are primarily in the direction of prevention, and, secondarily, in the direction of cure.
>
> Naturally, the expenses of such an organization are very large in the total amount and yet the cost per capita to the beneficiaries of the work is small. The cost of this work is divided between the Company and the employees, which is fair, as both derive benefit from it.
>
> The management of the Tennessee Coal, Iron and Railroad Company is convinced that the work is profitable, both to the employee and the Company, for many reasons. A dollar and cent reason is that from a given number of employees more days of work in the year are secured by a higher standard of health; each day's work is more productive by reason of a higher standard of vitality and ambition, and thus the employee, being paid, where possible, by the ton or piece, is able to earn a larger amount for the maintenance of his family in more decent living conditions than would be the case were he able to work less punctually and less efficiently.
>
> The benefits from the above conditions to the Company are obvious. For example, the labor turn-over in the Tennessee Coal, Iron and Railroad Company during the past ten years has been reduced to one-third of what it used to be, and the healthiness of mind, which generally accompanies an improvement in the health of the body, has made for more contentment and there is less friction between labor and management.
>
> The work done for the families of the workmen has probably been more appreciated by them than has the work which has been done for the workmen themselves; the relief of the workman from anxiety, which naturally attends sickness in the family,

in having his family in the hands of an adequate medical service, has been a great benefit.

The management of the Tennessee Coal, Iron and Railroad Company believes that the amount spent in the conduct of the Health Department of the Company has been a very profitable investment.

BOOK REVIEW

THE PRINCIPLES OF PUBLIC HEALTH ENGINEERING. By *Earle B. Phelps*, B.S., Professor of Sanitary Science, College of Physicians and Surgeons, Columbia University; Formerly Associate Professor of Chemical Biology, Massachusetts Institute of Technology. Cloth. Pp. viii, 265 with index. New York: The Macmillan Company, 1925.

The author treats the principles rather than the practice of public health engineering, for the benefit of the public health officer who has little engineering training and for the sanitary engineer who is unfamiliar with the principles of public health.

The first chapter deals with the relation and dependence of life upon its environment. The efforts of the public health officer are directed toward determining the most favorable conditions for the health and well-being of the human species. With these fundamental data in hand it is within the province of the engineer to design the proper equipment for the control of the environment.

In the second chapter the author begins with atmospheric pollution, thus introducing the reader to the principles of ventilation. Natural and artificial ventilation and their relative merits are discussed in Chapter III. The discussion is based, however, entirely on the result and conclusions of the New York State Commission on Ventilation, whose reports are quoted frequently, and therefore it does not represent the conservative judgment of practical men in industry.

The subject of municipal water supply is treated with considerable detail in Chapters IV and V. Valuable experimental data are given on filtration, chlorination, softening, and other treatment of water, with details of representation, sand filter constructions and sand washing apparatus.

The sixth chapter is devoted to sewerage. It includes sewers, plumbing, and sewage treatment and disposal. In connection with the last, the author recommends the chlorine treatment on the basis of his extensive investigations at the Massachusetts Institute of Technology and at Baltimore.

Another important subject related to public health is the pasteurization of milk, which constitutes the seventh chapter. North's time-temperature chart for pasteurization is most interesting. It confirms Rosenau's findings and shows that a temperature of 142°F. maintained for thirty minutes will render harmless the most resistant of the pathogenic bacteria likely to be found in milk, without detriment to its physical or chemical properties.

The chapter ends with descriptions of pasteurization processes and modern mechanical equipment.

Lighting, its relation to ventilation, its physical and physiologic principles, and a discussion of natural and artificial lighting constitute the eighth chapter.

Miscellaneous environmental control, the last chapter of the book, includes the collection and disposal of municipal refuse, and the control of the mosquito and the fly, under various environmental conditions.

This book is a valuable contribution to the science of public health engineering, in that it brings together from widely scattered sources the principles and practice of this science. The presentation is brief and not too technical for the medical student or the engineer.—*C. P. Yaglou.*

Officers, Committees, and Membership of the Section on Industrial Hygiene of the American Public Health Association

At the St. Louis Meeting of the American Public Health Association held Oct. 19–22, 1925, the following officers and committee members were named for the year 1925–1926:

Section Officers:

Chairman, Dr. Thomas R. Crowder, Director, Sanitation and Surgery, Pullman Co., Chicago, Ill.

Vice-Chairman, Dr. V. J. Cheney, Medical Director, Armour & Co., Chicago, Ill.

Secretary, Dr. E. R. Hayhurst, Professor of Hygiene, Ohio State University, Columbus, Ohio.

Members of Section Council, in addition to the officers *ex officio:*

a. Term expires Annual Meeting, 1926:

Dr. Eugene L. Fisk, Life Extension Institute, New York City.

Dr. George M. Price, Joint Board of Sanitary Control, New York City.

b. Term expires Annual Meeting, 1927:

Dr. Francis D. Patterson, P. O. Box 4061, West Philadelphia, Pa.

Dr. F. L. Rector, The Nation's Health, Chicago, Ill.

Dr. Henry F. Smyth, Assistant Professor of Hygiene, University of Pennsylvania, Philadelphia, Pa.

Dr. Leonard Greenburg, U. S. Public Health Service, New Haven, Conn.

Named as Section representative to the *Committee on Eligibility:*

Dr. A. J. Lanza, National Health Council, New York City.

Committee on Extension of Industrial Hygiene:

Chairman, Dr. George M. Price, Joint Board of Sanitary Control, New York City.

Vice-Chairman, Dr. F. L. Rector, The Nation's Health, Chicago, Ill.

Dr. C. P. McCord, Cincinnati, Ohio.

Dr. C. D. Selby, Toledo, Ohio.

Dr. W. S. Bean, U. S. Public Health Service, Washington, D. C.

Committee on Painters' Hazards:

Chairman, Dr. Wade Wright, Metropolitan Life Insurance Co., New York City.

Vice-Chairman, Dr. Leonard Greenburg, New Haven, Conn.

Miss Ruth M. Hutton, Toronto, Canada.

Dr. Alice Hamilton, Boston, Mass.

Committee on Industrial Anthrax:

Chairman, Dr. H. F. Smyth.

Dr. V. S. Cheney, Chicago, Ill.

Dr. S. Dana Hubbard, New York City.

Dr. Stanley H. Osborn, Hartford, Conn.

Committee on Industrial Morbidity Statistics:

Chairman, Dr. Wade Wright, Metropolitan Life Insurance Co., New York City.

Dr. F. L. Rector, The Nation's Health, Chicago, Ill.

Dr. George H. Van Buren, Metropolitan Life Insurance Co., New York City.

Committee on Program for the 1926 Meeting at Buffalo:

The Officers of the Section.

Section representative to *Committee on Training of Public Health Sanitarians*, the representative instructed to select such others from the Section as he desired for an Advisory Committee:

Dr. E. R. Hayhurst, Columbus, Ohio.

The Section Chairman was empowered to appoint a committee from the Section to assist Mr. James A. Tobey in his work on the extension of "Interstate Control of Poisons and Hazardous Substances Other than Foods."

In addition, the applications of Horace J. Howk, M.D., Mt. McGregor, N. Y., and Charles J. Prest, M.D., Brooklyn Tuberculosis Committee, for affiliations as Fellows were approved; the applications of C. T. Graham-Rogers, M.D., New York City, and Miss Ruth Hutton, Toronto, Canada, for Fellowship were approved, and the names of 25 applicants for Membership were approved.

Section membership—39 Fellows, 125 Members: total, 164.

EMERY R. HAYHURST, M.D.,
Secretary.